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(54) OIL POLLUTANT CONFINING AND RECOVERING METHODS AND APPARATUSES

(71) We, BENNETT POLLUTION CONTROLS LTD., a body corporate organised and existing under the laws of Canada, of 119 Charles Street, North Vancouver, B.C., Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to methods and apparatuses for confining and recovering oil pollutants from the surface of a body of water.

An oil spill recovery apparatus has been proposed which comprises a floating boom which may be used to surround an oil slick and which is constructed of a flexible weighted net supported in a vertical position by elongated flotation units mounted on one or both sides of the net, with part of the net projecting some distance above the water's surface as a splash or wave barrier and with the remainder projecting beneath the water's surface. The net beneath the surface is comprised of a filtering hydrophobic, oleophilic construction enabling water to flow through it but serving as a barrier to passage of liquid hydrocarbons.

According to the present invention, there is provided a method of confining and recovering oil pollutants from the surface of a body of water by means of elongated floating booms which include an above-water barrier portion and an adjoining below-water barrier portion, which latter portion is substantially oleophilic and hydrophobic so as to permit passage of water therethrough while barring passage of oil pollutants, the method comprising deploying two such elongated booms in floating position side-by-side, positioning the respective booms in mutually convergent relationship with their divergent ends forming a relatively wide entrance for the inflow of oil pollutant on the surface of the body of water and their convergent ends forming a recovery throat into which the oil pollutant can be funnelled by the booms, cross-connecting the booms at a plurality of corresponding locations spaced successively from the said convergent ends towards said divergent ends, to limit the divergence angle between the booms adjacent their convergent ends and collecting from the surface of the body of water oil pollutant which is concentrated in said recovery throat by virtue of a relative motion between the booms and the water in a direction to effect the aforesaid funnelling action.

The invention also provides apparatus for confining and recovering oil pollutants from the surface of a body of water comprising a pair of elongated flexible booms each having an above-water barrier portion and a below-water barrier portion, the latter portion being oleophilic and hydrophobic so as to permit passage of water therethrough while barring passage of oil pollutants, means on the booms to cause the booms to float with said portions in a substantially upright position, means at a first end of each of said booms for connecting the respective boom to an anchorage or a towing means whereby in use the booms are positioned in a mutually convergent relationship, means cross-connecting the booms at corresponding locations spaced successively on the booms from their convergent ends towards their divergent ends, to limit the divergence angle between the booms adjacent their convergent ends, and an oil pollutant recovery means to collect oil pollutants confined between the booms from between the convergent ends of the booms.

An oil confining and recovering method and apparatus according to the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a plan view of the apparatus,

Figure 2 is a schematic sectional view of a filtration boom used in the apparatus,

Figure 3 is a perspective view of the boom,

Figures 4, 5 and 6 are respectively top, side and end views of a combined tow bar and float structure used at the leading end of each boom,

Figure 7 illustrates a bridle arrangement

by which the convergent ends of the two booms in the apparatus are held against spreading at intervals along their lengths,

Figure 8 is a perspective view of the manner in which the trailing end of a boom is secured to a skimming or oil lift device, permitting relative pitching and rolling motion without appreciable escape of oil.

Referring firstly to Figure 1, the apparatus comprises two mutually convergent booms B1 and B2 which are deployed as shown by securing the convergent ends B1′ and B2′ thereof to an oil barge 14 or the like and by securing their mutually opposite or divergent ends, respectively designated B1″ and B2″, to tugboats labelled 1 and 2 in Figure 1. In Figure 1 the oil slick is deemed moving by current relatively to the boom system towards the convergent ends of the booms B1 and B2, and the function of the tugboats 1 and 2 is to maintain the divergent ends of the boom spread apart the appropriate distance and maintain the booms B1 and B2 spread apart under some tension for positioning them as a funnel against the flow forces of the current. At the downstream end where the two booms converge together, there is mounted a skimming or oil lift device 10 such as is shown in Canadian patent No. 735,254, and this feeds its output through a pipe or conduit 12 into the oil barge 14. The oil barge 14 itself may be secured in position by means of a tugboat 13 in order to maintain tension in the entire boom system against the forces exerted by the tugs 1 and 2 and also as a means to coordinate the positioning of the apparatus in relation to the location and motion of the oil slick.

In a typical situation the oil slick will be emanating from a given point of origin such as a ruptured offshore well head or pipe or from a ruptured tanker. In most waters there is current flow and the slick soon moves away from the point of origin in a downstream direction and becomes spread out over a long distance. The boom system of Figure 1 intercepts the moving slick by a technique which recognizes that it is not feasible or practical in most instances to surround a spreading slick of oil but it is possible in most cases to intercept it or to move in paths which successively divide it and collect it by segments or zones until virtually all of the oil has been recovered and removed as a hazard to the adjacent environment.

Therefore in accordance with this invention, when a spill occurs the boom system operators immediately secure the towing or lead ends B1″ and B2″ of the two booms B1 and B2 in towing position to the tugs 1 and 2 by means of hawsers or cables 18 connected to tow bar structures 20 of the respective booms and, with the oil barge and associated apparatus secured to the convergent ends B1′ and B2′, move the assemblage of booms and associated barge to the scene with or without the tug 3 fastened to the barge 14; preferably with it fastened, however, in order to control the position of the trailing end of the boom system as it moves into position through crosscurrents and sometimes in narrow passages which curve and thereby require attention and guidance at both ends of the towed system. Once the system reaches its initial operating position the angle of spread labelled X in Figure 1 is determined by control from a suitable point such as from one of the tugboats or from the barge 14, directing the operations of the other boats through radio control. It has been found that the relative current flow rate of the water determines the best choice of divergence angle X between the booms. For example, it is found that the angle X at three knots of relative current flow should be about 60° whereas at five knots it should be about 45° and at eight knots about 30°. Under these conditions positioning tension in the booms is adequate yet not excessive considering the fact that an excessively divergent boom arrangement for a given current flow tends to increase the chances of escapement, and an insufficient spread angle of course unduly restricts the receiving width at the entrance of the funnel formed by the booms B1 and B2.

Bridles 21 are provided as shown in Figures 1 and 7 to cross-connect the two booms near the convergent ends thereof such as at stations respectively 10 feet, 30 feet, 70 feet and 100 feet from the skimming device 10, each cross-connecting bridle 21 being secured to one of the boom posts 22 to be described hereinafter, by means of a bridle cable fastened to the top and bottom ends of the boom posts. Thus at the funnelling or convergent end of the boom system the angular relationship of the two booms is closely controlled and maintained by the cross-connecting bridles 21 at a relatively shallow or narrow angle of convergence such as the order of about 30° for a distance along the length of the combined booms of approximately 100 feet, irrespective of the divergence of the booms beyond the bridles 21. By fixing the angle in this manner, the concentrating flow of oil will move in a steady predictable pattern to concentrate at the maw of the skimming device 10 which picks the oil up from the water's surface and delivers it to the barge 14.

Referring now to Figure 2, each boom B comprises an upper section B*a* and a lower section B*b*. In a typical case, such as for offshore applications in heavy seas, the upper section will project above the water's surface by approximately two and one half feet, whereas the lower section will extend downwardly below the water's surface approxi-

mately three and one half feet. The lower section is of oleophilic, hydrophobic material and permits sea water but not oil to flow through the lower section, whereas the upper section is impervious to flow of any kind, preferably comprising a vinyl or similar covering layer. Float assemblies P1 and P2 are disposed on respectively opposite sides of the boom to support the boom so that it extends horizontally across the surface of the water, whereas suitable stabilising means, such as weights mounted on the lower edge portion of the boom, maintain it stably in an upright position as depicted.

In reference to construction of the boom itself, as shown in Figure 3 substantially the entire height of each boom is supported and reinforced by galvanized vinyl-covered steel chain-link fence 30 strung in sections between and supported by the boom posts 21 formed by galvanized heavy steel pipe and located at 3 foot intervals along the length of the boom. Typically, the boom is made in 100-foot long sections measured end-to-end of stringer cables 24 which pass through tubular fittings 26 at the respective top and bottom ends of the boom posts 22 and are held therein against relative sliding by swaged or pressed grommets 28. An intermediate stringer cable 32 similarly extends through corresponding fittings 28 at intermediate points on the length of the boom posts 22, locating such cable 32 substantially at the surface level of water in which the boom is to float. The float assemblies P1 and P2 comprise elongated polyethylene or similar foamed plastics floats 36 extending lengthwise of the boom on respectively opposite sides thereof and fastened to the posts 22 by means of rope ties 38 and associated fittings 40 (Figure 2), the details of which may vary and are not of particular moment herein. Weights or stabilizers in the form of lead slugs 43 are positioned at the bottom edge of the boom at intervals along the length thereof to assure that the boom will float in an upright position as depicted in Figure 2.

The upper or above-water fence barrier section B*a* of the boom is provided by a folded sheet or strip or vinyl material 42 which is impervious both to water and to oil and which drapes over the top cable 24 and the chain-link fence 30 at approximately the midline of the strip 42 to form an equal fold. The bottom or filter section B*b* of the boom B comprises oleophilic, hydrophobic strips or panels 44*a* and 44*b* placed on respectively opposite sides of the boom fence 30 and sewn for support to the lower edges of the folded vinyl strip 42 draped over the structure. The floats are secured to the posts and to the reinforcing fence panel at positions spaced along the length of the boom.

At the towing or leading end of each boom the post 22L, which is secured to the leading ends of the cables 24, 32 and to the leading edge of each chain-link fence panel, passes through a hollow boat-shaped float 46. The front or stem end of this float is provided with a towing bar 46*a* having holes 46*a*′ therein selectively engageable by a shackle pin so as to secure the float for towing purposes to a tow cable made fast to one of the tugs 1 and 2. The post 22L is appropriately welded or otherwise fastened to a receiving collar 46*b* extending through the float 46 between top and bottom thereof (Figures 5 and 6). The float 46 is manufactured of $^1/_8$ inch mild steel welded together and galvanised as a boat-like structure. Its function is to float and to stabilise the leading end of the boom being towed by one of the two tugs 1 and 2.

In Figure 8, the skimming device 10 is shown as having on each side adjacent its leading end coupler collars 50 placed in upright aligned positions. A short length of boom section 54 has an upright stiffener 56 at its trailing end to and along which a length of coupler pipe 58 is welded. A lock pin 60 can be inserted through the aligned collars 50 and pipe 58 so as to secure the section of boom 54 closely to the side of the skimming device 10. The opposite end of the section of boom 54 is provided with a stiffener secured by suitable clamping means 62 to the trailing end of the boom being towed. The towing force is born primarily by a tow bar 64, however, which is coupled for universal pivoting at its leading end for pivoting through shackles 68 to a tow bar float (not referenced) carried by the boom.

In use it will be possible in some situations for the tugboats 1 and 2 to be replaced by permanent installations using for example mooring buoys which are anchored in position, or by dolphins, assuming the current is steady and will flow in the same direction during usage. As a practical matter, however, ocean and other tide-water currents vary in direction and rate of flow, so that for most practical purposes it is expected that the boom system will almost always be operated with moving vessels such as tugboats 1 and 2 connected to the towing end elements 20 of the two booms. It will be noted that standard tugs can be used to operate the boom system, without extensive remodelling of the tugs.

Likewise, it is anticipated that because of the variability in flow and direction of currents and the changing locations of the oil slicks to be confined and collected, the manoeuverability at the convergent end of the booms where the oil barge 14 or other oil-collecting device and the associated skimming device 10 are located should also be under control of and positioned in terms of geographic coordinates and direction by a tugboat or other vessel having motive power

and steerage. In this way it is possible to adapt the position, orientation and angle of divergence of the two booms B1 and B2 to suit current velocity and direction at any time, and thereby, through co-ordinated manoeuvering of the vesels, to intercept the maximum proportion of the total slick. If in one pass of the slick the entire amount of oil spread upon the water is not collected, then it is possible to manoeuver the assembly around, overtake the slick and repeat the process for the portion that escaped in the initial pass. This may be done one or more times until the entire slick has been collected, or it may be done with two or more assemblies similar to that shown in Figure 1 work-in in echelon or side-by-side relationship for intercepting a relatively wide slick.

In any case the manoeuverability of the apparatus and the versatility of the technique suits the invention for emergency use in almost any waters. The booms lend themselves to be stowed in folded or rolled condition on docks or on tugs ready for instant deployment and use. The materials are durable and capable of prolonged and repeated exposure. The coupling arrangements minimise losses by leakage. Flexibility to accommodate swells even as high as 12 feet or more is achieved. The characteristics of the boom avoid losses by flow occurring beneath the lower edge of the boom, because the relatively free water flow passing through the boom, even at the higher current velocities at the convergent collecting end of the boom, is found to be adequate to prevent the concentrating oil from piling up and flowing downwardly with water currents at that location due to build-up of water pressure by the funelling action. Likewise projection of the impervious portion of the boom as a barrier above the surface of the water is adequate to prevent spill-over due to wave action or pile-up of water from relative current flow and convergence of the two booms.

It has been found that the booms can be rapidly deployed and can recover about 90% of an oil slick in six foot seas and nearly the whole of a slick under more favourable conditions.

WHAT WE CLAIM IS:—

1. A method of confining and recovering oil pollutants from the surface of a body of water by means of elongated floating booms which include an above-water barrier portion and an adjoining below-water barrier portion, which latter portion is substantially oleophilic and hydrophobic so as to permit passage of water therethrough while barring passage of oil pollutants, the method comprising deploying two such elongated booms in floating position side-by-side, positioning the respective booms in mutually convergent relationship with their divergent ends forming a relatively wide entrance for the inflow of oil pollutant on the surface of the body of water and their convergent ends forming a recovery throat into which the oil pollutant can be funnelled by the booms, cross-connecting the booms at a plurality of corresponding locations spaced successively from the said convergent ends towards said divergent ends, to limit the divergence angle between the booms adjacent their convergent ends and collecting from the surface of the body of water oil pollutant which is concentrated in said recovery throat by virtue of a relative motion between the booms and the water in a direction to effect the aforesaid funnelling action.

2. A method according to claim 1 wherein the divergent ends of the respective booms are towed respectively by two vessels powered and navigated to maintain the relative position of the booms and to establish said relative motion between the booms and the water, and wherein the convergent ends of the booms are maintained in tow by a third vessel working co-operatively with said two vessels.

3. A method according to claim 1 or claim 2 wherein the angle of divergence of the booms is related to the speed of the relative motion between the booms and the water approximately as follows:

Speed	*Angle*
3 knots	60°
5 knots	45°
8 knots	30°

4. Apparatus for confining and recovering oil pollutants from the surface of a body of water comprising a pair of elongated flexible booms each having an above-water barrier portion and a below-water barrier portion, the latter portion being oleophilic and hydrophobic so as to permit passage of water therethrough while barring passage of oil pollutants, means on the booms to cause the booms to float with said portions in a substantially upright position, means at a first end of each of said booms for connecting the respective boom to an anchorage or a towing means whereby in use the booms are positioned in a mutually convergent relationship, means cross-connecting the booms at corresponding locations spaced successively on the booms from their convergent ends towards their divergent ends, to limit the divergence angle between the booms adjacent their convergent ends, and an oil pollutant recovery means to collect oil pollutants confined between the booms from between the convergent ends of the booms.

5. Apparatus according to claim 4 wherein each of the booms comprises a length of metal chain-link fencing of a width extending substantially the full height of the com-

bined above-water and below-water portions, a strip of covering material impervious both to water and to oil pollutants and draped over the uper edge of said fencing in an equal fold, the sides of which extend downwardly from said upper edge substantially to the water level of the boom when floating, and strips of oleophilic, hydrophobic material secured to the lower edges of the folds of the covering strip and extending downwardly therefrom to substantially the lower edge of said fencing on respectively opposite sides thereof, each boom further having upright posts extending between top and bottom thereof at intervals along the length thereof, reinforcing cables extending lengthwise of the boom along the respective top and bottom edges of such fencing and at a position intermediate the top and bottom edges approximately at water level, and flotation means extending lengthwise of the boom and secured to and along the boom at said intermediate position.

6. Apparatus according to claim 4 or claim 5 wherein said connecting means at the first end of each boom comprises an upright rigid bar and a float means upon which the bar is mounted.

7. Apparatus according to claim 6 wherein the float means comprises a boat-shaped float having a securing element on the leading end thereof for securing a connecting line thereto.

8. Apparatus for confining and recovering oil pollutants from the surface of a body of water, substantially as hereinbefore described with reference to the accompanying drawings.

9. A method of confining and recovering oil pollutants from the surface of a body of water, substantially as hereinbefore described with reference to the accompanying drawings.

10. A system for confining and recovering oil pollutants from the surface of a body of water, comprising an apparatus according to any one of claims 4 to 7 and further including tug vessels connected respectively to said first ends of each of the booms, and a powered third vessel connected jointly to the second ends of the two booms.

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1344564 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

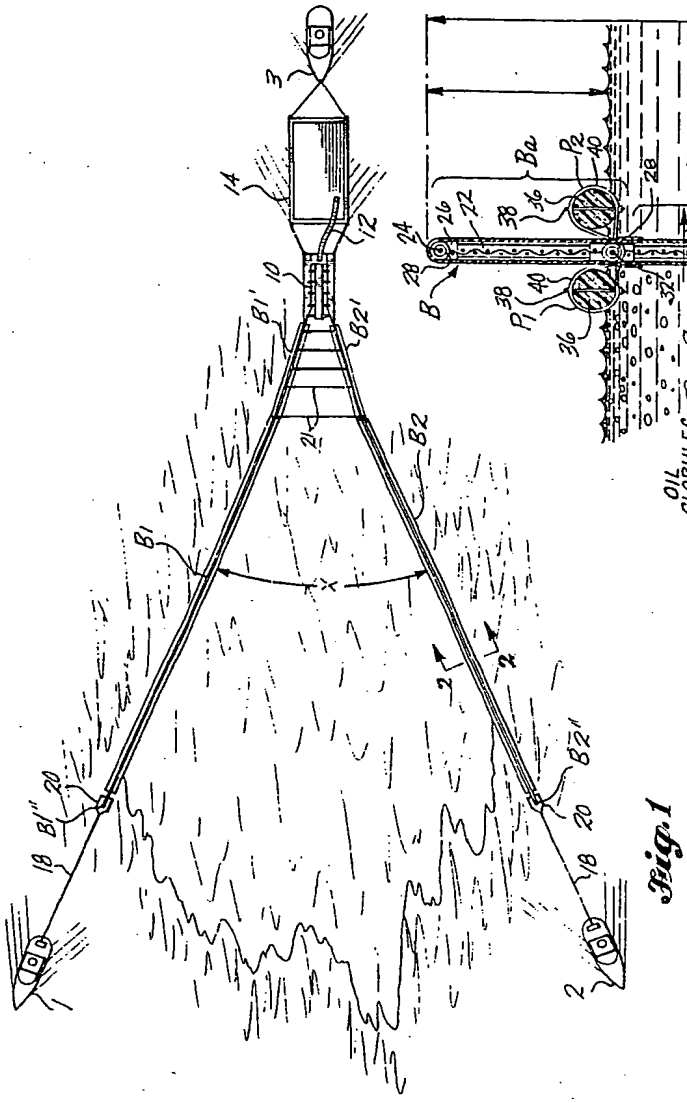


Fig. 1

Fig. 2

1344564 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

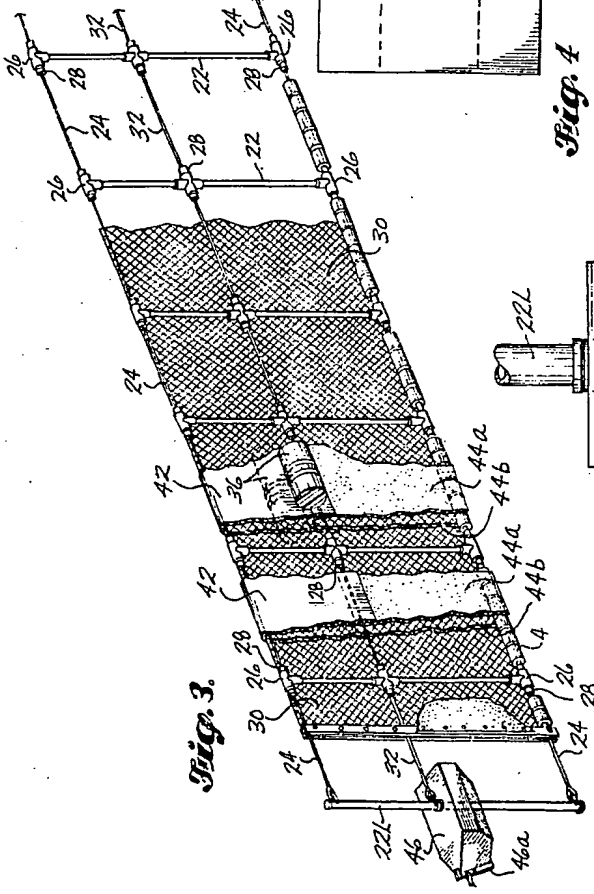


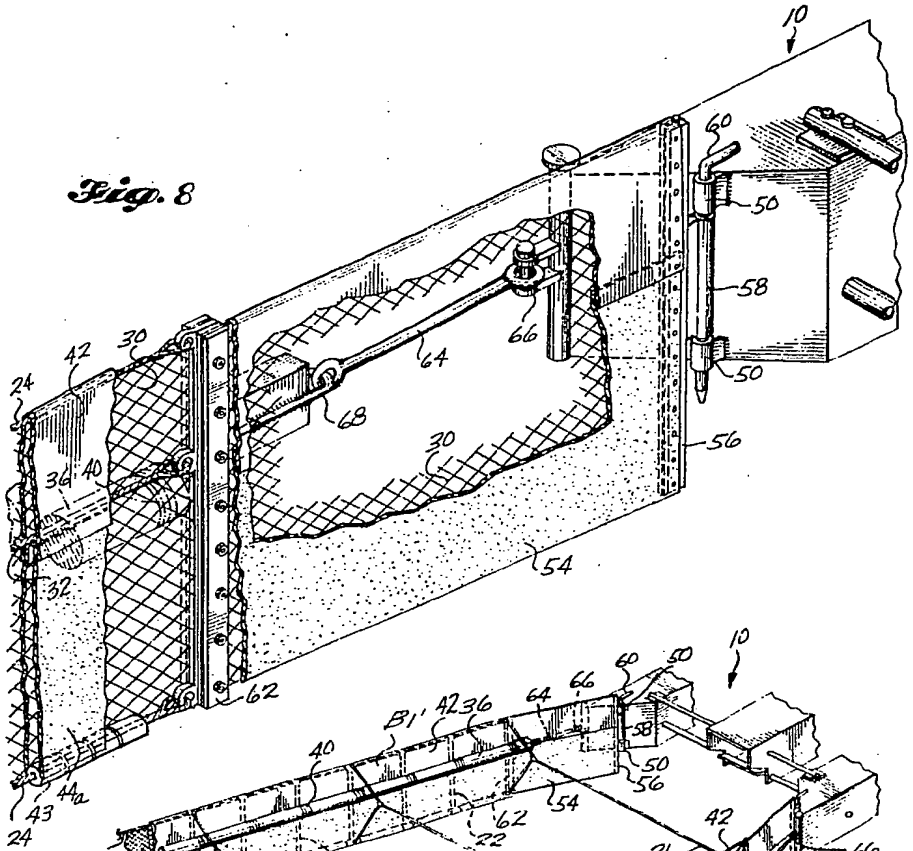
Fig. 3.

Fig. 4

Fig. 5

Fig. 6

Fig. 8



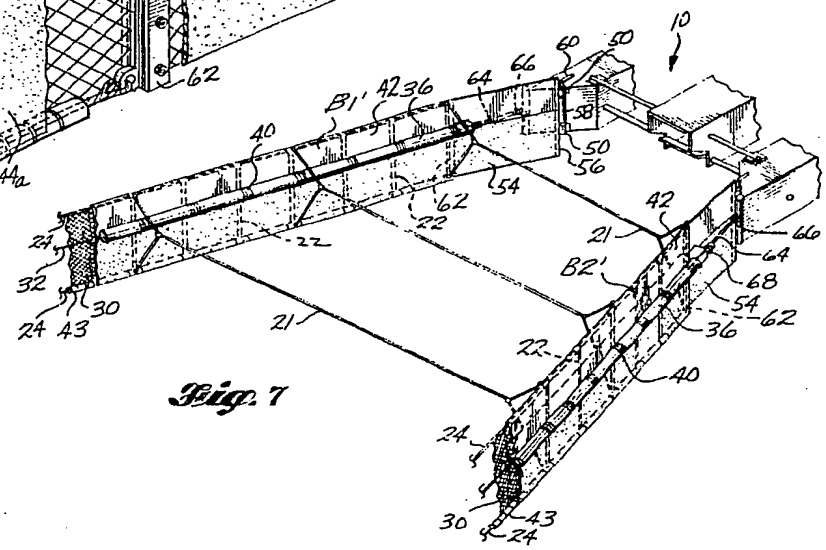


Fig. 7